TECHNICAL SPECIFICATIONS

Biogas Purification & Compressed Biogas (CBG) Production Plants

Bangalore Water Supply and Sewerage Board (BWSSB), Bengaluru

Contents

1. PROJECT OVERVIEW....4
1.1 Objectives....4
2. PROJECT SITE DETAILS....4
2.1 Site Details....4
2.2 Site Conditions....5
2.3 Site Allocated Area....5
2.4 Battery Limits....5
2.5 Area Classification....5
3. BIOGAS QUALITY....6
3.1 Raw Biogas Quality....6
3.2 Product Biogas Quality Requirements....6
4. MINIMUM PROCESS REQUIREMENTS....7
4.1 Double Membrane Biogas Storage Balloon....7
4.2 H_2S Removal System (Chemical Scrubber)....7
4.3 Dehumidification System....7
4.4 Activated Carbon Filtration....7
4.5 Biogas Upgrading – VPSA System....8
4.6 Membrane Polishing Unit....8
4.7 CBG Compression System....8
4.8 Automation and Control....8
5. GENERAL TECHNICAL REQUIREMENTS....8
5.1 Operational Requirements....8
5.2 Standards Compliance....8
5.3 Documentation Requirements....9
6. MAJOR EQUIPMENT SPECIFICATIONS....9
6.1 Double Membrane Biogas Storage Balloon....9
6.2 H_2S Scrubber....10
6.3 Dehumidification System....11
6.4 Activated Carbon Filtration Unit....11
6.5 VPSA Biogas Upgrading System....12
6.6 Membrane Polishing Unit....13
6.7 CBG Compressor System....14
6.8 Online Gas Analyzer / Gas Chromatograph....15
7. SCADA & AUTOMATION SYSTEM....16
8. GAS SAFETY, PRESSURE REGULATION & METERING....17
8.1 Pressure Regulating Skid (PRS)....17
8.2 Metering Skid....17
8.3 Gas Detection & Safety Systems....17
8.4 Auto-Isolation Triggers....17

9. ELECTRICAL SYSTEMS.....18
10. INSTRUMENTATION & CONTROL SYSTEM (ICSS).....19
11. MAJOR EQUIPMENT SUMMARY.....20
12. PLANT BUILDINGS.....20
12.1 Control and Monitoring Building With Electrical Panel Room.....20
12.2 Purification Plant PEB Enclosure.....21
13. ADMINISTRATION BUILDING CUM OFFICE.....22
13.1 Administration Building.....22
14. Operation & Maintenance (O&M) Requirements.....22
14.1 General O&M Requirements.....22
14.2 Civil Maintenance.....23
14.3 Mechanical Maintenance.....23
14.4 Electrical Maintenance.....23
14.5 Instrumentation Maintenance.....23
14.6 General Requirements.....24
14.7 Performance Guarantee Test Run (PGTR).....24
15. Suggested Vendors.....25
Annexure 1 – Location Key Maps of the proposed sites.....26
Annexure 2 – Indicative Layout of a Plant (15,000 m^3/day Capacity).....28
Annexure 3 – Indicative P&I Diagram (For Guidance Purpose Only).....29
Annexure 4 – Typical Schematic for Biogas Injection into CGD Steel/PE Pipe Network.....30
Annexure 5– Gas Generation Study.....31

1. PROJECT OVERVIEW

The scope of work under this Contract includes the design, engineering, procurement, manufacture, supply, installation, testing, commissioning, and operation & maintenance (O&M) of Biogas Purification and Compressed Biogas (CBG) Production Plants at identified Sewage Treatment Plants (STPs) under the Bangalore Water Supply and Sewerage Board (BWSSB), Bengaluru.

The system shall upgrade raw biogas generated from the anaerobic digesters / sludge digestion units at STPs into purified biomethane meeting the quality standards prescribed by the Petroleum and Natural Gas Regulatory Board (PNGRB) and the City Gas Distribution (CGD) network operator, suitable for injection into the natural gas distribution network.

The Concessionaire shall be responsible for the complete design, engineering, civil construction, equipment supply, installation, commissioning, and subsequent operation and maintenance of the plants throughout the concession period, in strict conformance with the technical specifications, applicable Indian Standards, and statutory requirements.

1.1 Objectives

- Upgrade raw biogas to pipeline-quality biomethane (Compressed Biogas – CBG).
- Ensure consistent delivery of CBG at the specified quality and pressure to the CGD network.
- Achieve safe, reliable, and continuous plant operation with minimum interruptions.
- Comply with all applicable statutory, environmental, and safety regulations.

2. PROJECT SITE DETAILS

2.1 Site Details

The following table provides site-wise information for the CBG plants to be established at the respective BWSSB Sewage Treatment Plants:

STP Location	Process Type	Capacity (MLD)	Gas Generation (m^3/day)	Area Limit (m^2)	BiogasPlants
K & C Valley – Site 1	ASP	150	8,400	4,000	One Biogas Plant for both STPs K&C Valley 150mld and K&C Valley 60mld combined
K & C Valley – Site 2	ASP	60	3,600		
Bellandur Amanikere	ASP	90	5,940	3,000	One Plant
Hebbal	SBR	100	2,000	3,000	One Plant
V Valley	ASP	150	8,550	3,000	One Plant

Note: The gas generation figures indicated above are based on current operational data and are provided for design reference. The Concessionaire shall verify actual gas generation rates at each site and design the plant accordingly. The area limits indicated are the maximum permissible plant footprint areas at each STP.

ASP – Activated Sludge Process | SBR – Sequencing Batch Reactor

Site location key maps are provided at Annexure 1.

2.2 Site Conditions

a) Ambient Temperature: 27° C; Minimum 15°C and Maximum - 45°C
b) Relative humidity – maximum 75%
c) Site conditions - tropical

2.3 Site Allocated Area

The entire facility at each of the location with all necessary buildings and structures, processing unit, storage infrastructure, all ancillary units, access roads, boundary relief, and administrative facilities shall be limited to the allotted areas by the Authority. All design and construction shall be planned and executed including necessary back up arrangements and to accommodate further scope of expansion to at least double the current installed capacity.

An indicative plant layout is shown at Annexure 2 for guidance purposes only. The Concessionaire shall proposed its own general alignment layout suited to each site in respective location.

2.4 Battery Limits

The battery limit of the Plant Facilities shall be as follows:

Unit	Inlet	Outlet
Purification Plant	At the inlet flange the delivery line from the existing raw biogas holder connecting the VPSA blower	At outlet flow meter flange connecting the Offtaker pipeline
Condensate drain from the de-humidifier	NA	Piping up to drain disposal trench identified and agreed by the Authority
Bypass flare line	NA	a) Outlet flange of product vessel b) Tapping after raw biogas feed blowers

2.5 Area Classification

Electricals and instrumentation supplied for Plant Facilities shall be suitable for the applicable Area Classification as specified here.

Except for the following area, all other equipment and area will be termed as safe area. These listed areas are Hazardous IIA / IIB and all equipment and instruments, electricals, field junction boxes, field panels, remote on/off station for operation installed in field will comply with hazardous area IIA / IIB classification.

i. Biogas Storage Area

ii. Biogas Scrubbing
iii. Biogas Purification and Co2 Removal Area
iv. CBG Compressors and compression Area

3. BIOGAS QUALITY

3.1 Raw Biogas Quality

The indicative raw biogas quality presented in the tables below were obtained during the Techno-Economic Feasibility Report (TEFR) Study. An extract of the TEFR is provided at Annexure 5 of this Specifications. The indicative values are provided in the table below is for general guidance purposes only and are not binding on BWSSB in any manner. The actual raw biogas quality at each STP may vary from the indicative ranges shown, and the Concessionaire shall not be entitled to any claims or additional compensation on account of any deviation from these values. The Concessionaire shall be fully responsible for conducting its own independent studies, sampling, and testing to ascertain the actual raw biogas quality and composition at each STP site, prior to finalising the plant design. BWSSB shall not be held responsible or liable for any variance in raw biogas quality from the TEFR indicative values.

Name of STP	Quality observed in the biogas generated before scrubbing							
	Methane content (%)	Carbon dioxide (%)	Hydrogen Sulphide (%)	Nitrogen (%)	Water Vapour (%)	Hydrogen (%)	Siloxanes (%)	Ammonia
Hebbal	58.0	36.0	1.20	0.83	2.20	0.60	0.02	1.10
V Valley	66.5	31.0	1.10	0.20	0.90	0.05	0.00	0.20
K & C Valley 150	67.0	31.0	0.80	0.30	0.60	0.02	0.01	0.22
K & C Valley 60	62.2	33.5	1.10	0.70	1.40	0.20	0.05	0.80
Bellandur	65.2	31.6	1.10	0.60	1.10	0.10	0.01	0.24

The purity of biogas after dehumidifier and scrubbing observed during the laboratory study is as follows.

Name of STP	Quality observed in the biogas generated after dehumidifier and scrubbing							
	Methane content (%)	Carbon dioxide (%)	Hydrogen Sulphide (%)	Nitrogen (%)	Water Vapour (%)	Hydrogen (%)	Siloxanes (%)	Ammonia
Hebbal	69.0	29.0	0.01	0.05	1.60	0.20	0.00	0.09
V Valley	72.0	26.9	0.01	0.05	0.90	0.05	0.00	0.08
K & C Valley 150	73.0	26.0	0.02	0.06	0.60	0.02	0.01	0.24
K & C Valley 60	70.2	27.6	0.02	0.05	1.20	0.10	0.00	0.78
Bellandur	71.5	27.1	0.04	0.05	0.98	0.20	0.00	0.08

3.2 Product Biogas Quality Requirements

The purified biomethane / CBG delivered at the supply point to the CGD network shall conform to the following minimum quality parameters in compliance to IS 16087 (Specification for Bio-Gas/Bio-Methane for Use as Automotive Fuel and for Injection in the Natural Gas Grid) and as prescribed by the Petroleum and Natural Gas Regulatory Board (PNGRB):

Parameter	Unit	Required Value / Specification
Methane (CH_4)	mole %	≥ 95 (minimum, dry basis)
Moisture (H_2O)	mg/Nm³	≤ 5
Hydrogen Sulphide (H_2S)	mg/Nm³	≤ 3.7
Total Sulphur (incl. H_2S)	mg/Nm³	≤ 10
Carbon Dioxide (CO_2)	mole %	≤ 4
CO_2 + N_2 + O_2 Combined	mole %	≤ 5
Oxygen (O_2)	mole %	≤ 0.5
Hydrocarbon Dew Point	°C at pipeline pressure	≤ 0°C
Maximum Gas Temperature	°C	≤ 55°C
Delivery Pressure (at CGD supply point)	bar g	20 bar (pressure-controlled termination)

Note: All quality parameters shall be measured on a dry gas basis unless otherwise specified. The Concessionaire shall ensure continuous online monitoring and control of product gas quality to maintain compliance with the above specifications throughout the operation period.

Additional Requirements: The technical standards for the proposed biogas purification and distribution shall comply to the PNGRB (Technical Standards and Specifications including Safety Standards for City or Local Natural Gas Distribution Networks) Regulations, 2008 – Technical Standard TS-1 (Quality specifications for biomethane / CBG at CGD injection point) shall be explicitly referenced and complied with for all product gas quality requirements.

4. MINIMUM PROCESS REQUIREMENTS

The CBG production plant at each STP shall incorporate, as a minimum, the following process equipment and systems. An indicative P&ID Diagram is provided in Annexure 3 for guidance purpose only. The Concessionaire may propose additional equipment or process steps to meet the guaranteed performance parameters:

4.1 Double Membrane Biogas Storage Balloon

a) Minimum storage capacity: 1,500 m³.
b) Provides buffer storage and pressure stabilization for raw biogas prior to purification.

4.2 H_2S Removal System (Chemical Scrubber)

a) Chemical H_2S scrubber designed for minimum 98% H_2S removal efficiency.
b) Protects all downstream equipment from corrosion and sulphur contamination.

4.3 Dehumidification System

a) Refrigerant-based dehumidification system with outlet dew point of 5°C.
b) Prevents moisture-related issues in adsorption beds and pipelines.

4.4 Activated Carbon Filtration

a) Dual-bed activated carbon filtration system in lead-lag configuration.
b) Provides final H_2S polishing and siloxane / VOC removal.

4.5 Biogas Upgrading – VPSA System

a) Vacuum Pressure Swing Adsorption (VPSA) system for CO_2 removal and methane enrichment.
b) Methane purity ≥ 95% and methane recovery > 96%.

4.6 Membrane Polishing Unit

a) Two-stage membrane polishing unit for methane enrichment up to ≥ 99% purity.
b) Incentivized provision for delivery of premium-quality biomethane.

4.7 CBG Compression System

a) Oil-free reciprocating compressors suitable for CGD injection and cascade cylinder filling.
b) Delivery pressure as required by CGD network operator.

4.8 Automation and Control

a) PLC-SCADA based fully automated operation.
b) Modbus TCP/IP communication for integration with field instruments.

5. GENERAL TECHNICAL REQUIREMENTS

5.1 Operational Requirements

a) The plant shall be modular and skid-mounted wherever feasible to facilitate future expansion.
b) Methane loss from the complete system (from biogas inlet to CBG supply point) shall not exceed 4%.
c) Minimum design life of all process equipment shall be 20 years; structural steel and civil works shall have a minimum design life of 50 years.

5.2 Standards Compliance

The Biogas Plant facilities shall comply with IS 9478:2023 – Design, Construction, Installation and Operation of Biogas (Biomethane) Plant – Code of Practice. The following Indian Standards (IS) and applicable international/industry standards shall govern the design, fabrication, testing and installation of each key component and system, as a minimum. Where General Specifications specify additional standards, those shall apply conjunctively. In case of conflict, the more stringent standard shall govern.

a) All process equipment shall be designed and manufactured in accordance with relevant IS, ASME, API, IEC, NFPA, and OISD standards.

b) All electrical and instrumentation equipment installed in hazardous areas shall comply with applicable ATEX / PESO requirements.

c) Hazardous area classification shall be carried out in accordance with IS 5572, with mandatory HAZOP / QRA by a third-party agency.

A. Biogas Plant – General

IS 9478:2023 – Design, Construction, Installation and Operation of Biogas (Biomethane) Plant – Code of Practice (BIS, MED 04 Committee)

B. Gas Piping and Pipework

a) ASME B31.3:2022 – Process Piping (primary piping code for all process gas piping within battery limits including biogas, biomethane and CO_2 vent piping)

b) IS 1239 (Part 1):2004 – Mild Steel Tubes, Tubulars and Other Wrought Steel Fittings – Mild Steel Tubes (for low-pressure biogas piping below 2 bar)

c) IS 17875:2022 – Stainless Steel Seamless Pipes and Tubes for General Service (for SS 304L/316L process gas and instrumentation tubing)

d) IS 14885:2001 – Polyethylene Pipes for the Supply of Gaseous Fuels (PE piping for low-pressure gas distribution and interconnection lines)

e) ASME B31.8 – Gas Transmission and Distribution Piping Systems (for high-pressure CBG delivery pipeline from plant boundary to CGD offtake at 20 bar g)

5.3 Documentation Requirements

The Bidder / Concessionaire shall prepare and submit the following engineering documents as part of the scope:

a) Process Flow Diagrams (PFD) and Piping & Instrumentation Diagrams (P&ID).

b) General Arrangement (GA) Drawings and Foundation Drawings for all major equipment.

c) Electrical Single Line Diagrams (SLDs) and Load Calculations.

d) Instrument Index, I/O List, and Cause & Effect Matrix.

e) Quality Assurance Plan (QAP) and Inspection & Test Plan (ITP).

f) Operation & Maintenance (O&M) Manuals.

g) As-Built Drawings for all civil, mechanical, electrical, and instrumentation works.

6. MAJOR EQUIPMENT SPECIFICATIONS

6.1 Double Membrane Biogas Storage Balloon

The double membrane storage balloon provides temporary buffer storage and pressure stabilization for raw biogas between generation and purification. The inner membrane contains the gas while the outer membrane maintains structural integrity using blower-supported air pressure. The system enables smooth flow balancing between variable biogas generation and downstream consumption.

Parameter	Specification
Type	Double Membrane Biogas Storage Balloon
Applicable Standards	i. IS 9478:2023 – Biogas Plant Code of Practice (covers gas holder / balloon design and installation requirements)

	ii. IS 2825:1969 (with Amendments) – Code for Unfired Pressure Vessels (for the inner gas containment membrane support structures and fittings) iii. IS 456:2000 – Plain and Reinforced Concrete Code of Practice (for RCC ring foundation and blower foundation) iv. IS 5572:2009 – Classification of Hazardous Areas (other than Mines) having Flammable Gases and Vapours for Electrical Installations (for area classification around balloon)
Minimum Storage Capacity	1,500 m^3
Inner Membrane Material	PVC with PVDF Coating
Outer Membrane Material	UV-Resistant, Weather-Proof Composite Fabric
Pressure Maintenance	Blower-Supported Air Pressure between Inner and Outer Membrane
Civil Works	RCC Ring Foundation and Blower Foundation
Suggested Makes	Sattler CENO / WELTEC BIOPOWER / BioGastechnik Süd GmbH

6.2 H_2S Scrubber

The H_2S scrubber removes hydrogen sulphide from raw biogas using a packed bed chemical scrubbing process. Biogas enters from the bottom of the vessel and flows counter-current to the scrubbing solution, ensuring maximum contact efficiency and absorption. The system protects all downstream equipment from corrosion and sulphur contamination, and improves gas quality before further purification stages.

Parameter	Specification
Type	Packed Bed, Counter-Current Chemical Scrubber
Applicable Standards	i. IS 2825:1969 (with Amendments) – Code for Unfired Pressure Vessels (vessel design, fabrication, testing and inspection) ii. ASME Section VIII Div. 1 – Rules for Construction of Pressure Vessels (where FRP vessel design deviates from IS 2825 scope) iii. BS EN 13121-3 / BS 4994 – GRP Tanks and Vessels for Use Above Ground (for FRP vessel with Isophthalic/Vinylester resin liner construction) iv. IS 5572:2009 – Hazardous Area Classification (Zone IIA/IIB equipment requirement) v. IS 5571:2009 – Guide for Selection, Installation and Maintenance of Electrical Equipment for Use in Potentially Explosive Atmospheres
Scrubbing Liquid	5% NaOH (Caustic Soda) Solution

Inlet H_2S (Design)	Up to 4,000 mg/Nm^3; up to 10,000 ppm (performance)
Outlet H_2S	< 50 ppm (indicative); ≤ 100 ppm (performance guarantee)
Removal Efficiency	> 98%
Gas Velocity	0.8 – 1.2 m/s
Vessel Material (MoC)	FRP with Isophthalic / Vinylester Resin Liner
Piping Material (MoC)	HDPE, FRP, or SS 316L
Pump Material (MoC)	SS 316L
Packing Material	Plastic Pall Rings or Saddles
Operating Pressure	Near Atmospheric
Area Classification	Zone IIA / IIB – ATEX / PESO Certified Equipment
Civil Works	RCC Foundation, Drainage Trench, and Access Platform
Suggested Makes	Pentair / CECO Environmental / Duall India

6.3 Dehumidification System

The refrigerant-based dehumidification system reduces moisture content in the biogas by cooling the gas below its dew point temperature. Condensed moisture is separated through a cyclonic separator and automatic drain arrangement. The process protects downstream adsorption beds and membrane systems, and prevents condensation-related issues in process pipelines.

Parameter	Specification
Type	Refrigerant-Based Chiller with Brazed Plate Heat Exchanger
Applicable Standards	i. IS 660:2018 – Safety Code for Mechanical Refrigeration (for refrigerant-based chiller system) ii. IS 659:2002 – Safety Code for Air Conditioning (for supplementary HVAC systems in the plant building) iii. IS 2825:1969 – Code for Unfired Pressure Vessels (for brazed plate heat exchanger vessel and condensate separator vessel) iv. ASHRAE Standard 15 – Safety Standard for Refrigeration Systems (for refrigerant containment and leak detection)
Inlet Biogas Temperature	25 – 40°C (saturated)
Target Outlet Dew Point	5°C
Inlet Pressure	50 mbar – 1.2 bar
Refrigerant Type	R134a or R407C
Refrigeration Load	~5.1 kW (1.45 TR) per 100 Nm^3/hr

Wetted Parts Material (MoC)	SS 316L throughout
Condensate Separator	Vertical Cyclonic with Demister Pad – SS 316L; >99% droplet removal (>5 µm)
Pressure Drop (Maximum)	50 mmWC
Drain Trap	Float-Type or Electronic Automatic Drain Valve (SS 316L)
Compressor Type	Hermetic / Semi-Hermetic Scroll or Reciprocating
Civil Works	RCC Foundation and Condensate Drain Pit
Suggested Makes	Parker Hannifin / SPX Flow / Atlas Copco

6.4 Activated Carbon Filtration Unit

The activated carbon filtration unit provides final polishing for removal of residual H_2S, siloxanes, volatile organic compounds (VOCs), and trace contaminants from the biogas stream. The system operates in dual-bed lead-lag configuration to ensure uninterrupted operation during carbon media replacement. Impregnated activated carbon efficiently adsorbs contaminants, protecting downstream compressors, membrane systems, and gas engines from harmful deposits and corrosion.

Parameter	Specification
Configuration	Dual-Bed (Lead-Lag) – Two Identical Vessels in Series
Applicable Standards	i. IS 2825:1969 (with Amendments) – Code for Unfired Pressure Vessels (dual-bed carbon filter vessel) ii. ASME Section VIII Div. 1 – Rules for Construction of Pressure Vessels (where vessel material is CS SA-516 Gr. 70 with Novolac Epoxy lining; applicable where IS 2825 scope is supplemented) iii. IS 3624:1994 – Specification for Pressure Gauges and Vacuum Gauges (for local pressure indication on filter vessels) iv. IS 9478:2023 – Biogas Plant Code of Practice (process safety and operational requirements for biogas purification equipment)
Target H_2S Outlet	< 3 ppm
Target Siloxanes Outlet	< 0.1 mg/Nm³
Carbon Type	Impregnated Activated Carbon (KI or Caustic Impregnated)
Carbon Lifespan	Minimum 12 months
Particle Size	4×8 or 4×12 mesh (~2.38 – 4.76 mm)
Vessel Material (MoC)	SS 316 or CS (SA-516 Gr.70) with Novolac Epoxy Lining (min. 300 µm DFT)

Design Pressure	2.5 bar g
Design Temperature	0°C to 50°C
Valve Type	Actuated Ball Valves – SS 316L Body, PTFE Seats
Civil Works	RCC Foundation and Access Platform
Suggested Makes	TIGG / CPL Activated Carbons / Jacobi Carbons

6.5 VPSA Biogas Upgrading System

The VPSA (Vacuum Pressure Swing Adsorption) system selectively adsorbs carbon dioxide and other impurities from the biogas stream using molecular sieve adsorbents. The process operates through cyclic pressurization and vacuum regeneration stages for continuous methane enrichment. The system ensures high methane recovery while minimizing methane losses to the atmosphere. This is the core upgrading technology for producing pipeline-quality biomethane.

Parameter	Specification
Technology	Vacuum Pressure Swing Adsorption (VPSA) – Selective Adsorption of CO_2 on Zeolite / Activated Carbon
Applicable Standards	i. IS 2825:1969 (with Amendments) – Code for Unfired Pressure Vessels (VPSA adsorber vessel design at 3–5 bar abs; vacuum vessel design at ~14 kPa abs) ii. ASME Section VIII Div. 1 – Rules for Construction of Pressure Vessels (for CS vessels with internal Novolac Epoxy lining or SS 316L vessels) iii. IS 9478:2023 – Biogas Plant Code of Practice (biogas upgrading system operational and safety requirements) iv. IS 5572:2009 – Hazardous Area Classification (Zone IIA/IIB for all equipment in the VPSA and CO_2 removal area)
Adsorbent Material	Zeolite 13X or Equivalent High-Purity Molecular Sieve
Inlet Pressure (to VPSA)	1.05 bar abs (post activated carbon filter)
Feed Adsorption Pressure	3 – 5 bar abs
Desorption Pressure (Vacuum)	~14 kPa absolute (0.1 – 0.3 bar inlet vacuum)
Product CH_4 Purity	≥ 95% (vol/vol, dry basis) – minimum guaranteed
Methane Recovery	> 96% (CH_4 loss ≤ 4% from complete system)
Product Pressure	8 bar
Vessel Material (MoC)	CS with Internal Novolac Epoxy Lining or SS 316L
Vacuum Pump Type	Liquid Ring or Dry Screw – SS 316L Wetted Parts
Operational Mode	Continuous, Fully Automated with HMI (minimum 15-inch colour touch screen)

Automation	PLC-Based; Modbus TCP/IP Communication; Auto Start/Stop
Civil Works	Heavy RCC Foundation with Anti-Vibration Pads
Suggested Makes	Xebec / Bright Renewables / Mahler AGS

6.6 Membrane Polishing Unit

The membrane polishing unit further enhances methane purity after VPSA treatment using polymeric membrane separation technology. Gas passes through semi-permeable membranes where carbon dioxide and trace gases selectively permeate at a higher rate than methane. The two-stage arrangement with permeate recycle improves methane recovery and overall gas quality. This unit is intended for the production of high-purity biomethane for premium CGD injection applications.

Parameter	Specification
Purpose	Further upgrade from 95% to ≥99% CH_4 purity (incentivized for premium CGD injection)
Applicable Standards	i. IS 2825:1969 (with Amendments) – Code for Unfired Pressure Vessels (for membrane housing design pressure 25 bar g) ii. ASME Section VIII Div. 1 – Rules for Construction of Pressure Vessels (SS 304L/316L shell at 25 bar g design pressure) iii. IS 5572:2009 – Hazardous Area Classification (Zone IIA/IIB for booster compressor and membrane area)
Membrane Type	Polymeric – Polyimide (PI) or Polysulfone (PSf)
Module Type	Hollow Fibre or Spiral Wound
Configuration	Two-Stage with Permeate Recycle
Feed Pressure	8 bar (from VPSA); boosted to 15 – 25 bar for membrane separation
Booster Compressor	Multi-Stage Reciprocating or Rotary Screw (ATEX Motor, Oil-Free Preferred)
Housing Material (MoC)	SS 304L / SS 316L
Design Pressure	25 bar g
CH_4 Recovery	99 – 99.5% of feed methane to membrane
Civil Works	RCC Skid Foundation and Drainage Arrangement
Suggested Makes	Air Liquide MEDAL / Evonik SEPURAN / Generon

6.7 CBG Compressor System

The compression system compresses purified biomethane for delivery to the CGD network injection point or for cascade cylinder filling applications. Oil-free reciprocating compressors

ensure contamination-free gas handling. Multi-stage compression with inter-stage cooling improves compression efficiency and controls operating temperatures.

Parameter	Specification
Type	Reciprocating, Oil-Free
Applicable Standards	i. ISO 13631:2002 – Petroleum and Natural Gas Industries – Packaged Reciprocating Gas Compressors (primary compressor design and performance standard; mandated for oil-free reciprocating type) ii. IS 11461:1985 – Code of Practice for Compressor Safety (safety requirements for compressor installation, guards, access, pressure relief) iii. OISD-STD-116 – Safety of Compressors and Turbines (mandatory cross-reference for oil industry installations; provides additional requirements on compressor safeguarding, relief devices, and interlock philosophy) iv. IS 7285 (Part 1):2004 – Refillable Seamless Steel Gas Cylinders (for cascade filling cylinders; design, inspection and testing of high-pressure cylinders up to 250 bar) v. IS 8451:2009 – Periodic Inspection and Testing of Seamless Steel Transportable Gas Cylinders (for in-service inspection of cascade cylinders) vi. OISD-STD-179 – Safety Requirements for Compression, Storage, Handling and Refuelling of CNG for Use in Automotive Sector (applicable to CBG compressor and cascade storage design) vii. IS 5572:2009 – Hazardous Area Classification (Zone IIA/IIB for compressor hall and compression area)
Service	Compress purified CBG from storage to cascade / CGD pipeline
Injection Pressure – CGD (MDPE)	3 – 5 bar
Injection Pressure – CNG Cascade	200 – 250 bar
Supply Point Pressure (at STP boundary)	20 bar (pressure-controlled termination)
Standby Arrangement	Adequate redundancy to ensure continuous supply
Field Trial Run	72 hours sustained operation at site, witnessed by IE / Authority

6.8 Online Gas Analyzer / Gas Chromatograph

The online gas analyzer continuously monitors methane, carbon dioxide, oxygen, hydrogen sulphide, and other gas quality parameters in real time. The system feeds data to the PLC-SCADA system for process control, optimization, and regulatory compliance monitoring. Automatic calibration and alarm functions ensure accurate and reliable performance throughout operation.

The analyser shall have the option to measure MMBTU, and gas flow at minimum 5 minute interval to measure both input and output gas and shall also measure methane loss in the process.

Parameter	Specification
Applicable Standards	i. IS 16087:2016 (with Amendments as applicable) – Specification for Bio-Gas/Bio-Methane for Use as Automotive Fuel and for Injection into Natural Gas Grid (defines product gas quality parameters the analyser must continuously monitor and confirm) ii. ISO 6976 – Natural Gas – Calculation of Calorific Values, Density, Relative Density and Wobbe Index from Composition (heating value calculation method for the analyser) iii. ISO 17025 – General Requirements for the Competence of Testing and Calibration Laboratories (for calibration gas standards; weekly calibration certificate requirement) iv. Legal Metrology Act 2009 / Indian Legal Metrology Certification – Required for fiscal and custody-transfer gas flow metering instruments (PESO certification as applicable)
Safety Approval	ATEX II 2G Ex db IIC T5 Gb; PESO / Indian Legal Metrology Certified
IP Rating	IP68
Ambient Temperature Range	0°C to +55°C
Analysis Components	CH_4, N_2, O_2, CO_2, H_2S, COS
Minimum Detection (CH_4, N_2, O_2)	50 ppm (0.005%)
Minimum Detection (CO_2, H_2S, COS)	2 – 5 ppm
Repeatability	< 0.03%
Accuracy	< 0.20% (single point calibration)
Analysis Cycle Time	5 minutes
Heating Value Calculation	As per ISO 6976
Calibration Gas Standard	ISO 17025 Accredited Laboratory; Weekly Calibration
Communication	Modbus Protocol; RS485 / Ethernet; 60-day Data Storage Minimum
Number of Channels	Minimum 2 Nos.

7. SCADA & AUTOMATION SYSTEM

The PLC-SCADA system shall provide centralized monitoring, control, and data logging of all process equipment and utilities. The automation system shall support remote operation capability, alarm management, historical data trending, and energy consumption monitoring. Industrial communication protocols shall be used for seamless integration of all field instruments.

Parameter	Specification
Applicable Standards	i. IEC 61511 – Functional Safety: Safety Instrumented Systems for the Process Industry Sector (for ESD logic, SIL level determination, safety function design) ii. IEC 60079 Series – Explosive Atmospheres (selection and installation of Ex-certified field instruments, transmitters, junction boxes in Zone 1 and Zone 2 areas) iii. IS 5571:2009 – Selection and Maintenance of Electrical Equipment in Explosive Atmospheres (mandatory for field instruments, gas detectors, flame detectors in hazardous zones) iv. IS 3624:1994 – Specification for Pressure Gauges and Vacuum Gauges (for all local process pressure gauges on vessels, filters, compressors and piping)
PLC Type	Industrial PLC-Based Automation with Dual Redundant Hot-Standby CPUs
SCADA Servers	Dual Redundant; Historian with minimum 7-year data storage
HMI	Minimum 15-inch colour touch screen, IP65; also at local RIO panels
Communication Protocol	Modbus TCP/IP; Redundant Managed Ethernet; Fibre Optic Backbone
Monitored Parameters	CH_4, CO_2, O_2, H_2S, Flow, Pressure, Temperature
Redundant I/O	Minimum 15% of critical I/O signals on redundant modules
Fail-Safe Logic	All outputs to safe/OFF state on power or control failure
FAT / SAT	Factory Acceptance Test and Site Acceptance Test mandatory
Surge Protection	SPDs on both ends of outdoor signal cables
Suggested Makes	Siemens WinCC / Schneider Eco-Struxure / Rockwell FactoryTalk

Each plant SCADA system shall have necessary communication and data transfer system for real time monitoring from the central Admin Building. It shall also be compatible to be integrated with the BWSSB central Command Centre at Shimsa Bhavan for monitoring purposes.

8. GAS SAFETY, PRESSURE REGULATION & METERING

8.1 Pressure Regulating Skid (PRS)

a) Active-monitor configuration with slam-shut valve and Creep Relief Valve (CRV).
b) Inlet/outlet isolation valves and Non-Return Valve (NRV) to prevent backflow.
c) Stage-wise pressure reduction as required; decompression skid with water heater for cascade injection.
d) Vent point: minimum 3 metres above the nearest working platform.

8.2 Metering Skid

a) Twin-stream metering configuration for uninterrupted measurement; AGA-standard based flow metering.
b) Real-time flow data shared with CGD / NGPL entity via Modbus communication.
c) Gas flow metering shall be installed upstream of the odorant injection point.
d) Calibration at ISO 17025 accredited laboratory; Calibration and Measurement Capability (CMC) ≤ ±0.5%.

8.3 Gas Detection & Safety Systems

a) Fixed flame-proof CH_4 gas detectors shall be provided at all critical locations: alarm activation at >20% LEL; automatic isolation at >40% LEL.
b) At least one portable gas detector shall be available on site at all times.
c) Emergency Stop (ESD) push buttons shall be provided at the control room, all process area entries, and adjacent to all compressors.
d) CCTV surveillance with minimum 60-day recording backup at all critical plant locations.

8.4 Auto-Isolation Triggers

The Emergency Shutdown (ESD) system shall automatically isolate the plant upon detection of any of the following conditions:

a) Pressure deviation beyond allowable limits.
b) Product gas quality deviation outside specified limits.
c) Odorization system failure (if applicable).
d) GC / Gas Analyzer power failure.
e) CH_4 detection at > 40% LEL.
f) Manual Emergency Stop activation.
g) Applicable standards shall be as follows:
    i. IS 5571:2009 – Guide for Selection, Installation and Maintenance of Electrical Equipment for Use in Potentially Explosive Atmospheres (for all field equipment in Zone IIA/IIB areas)
    ii. IS 5572:2009 – Classification of Hazardous Areas having Flammable Gases and Vapours for Electrical Installations (HAZOP/QRA basis; all plant area classification)
    iii. IS 3043:2018 – Code of Practice for Earthing (Second Revision) (separate PLC/DCS earthing; overall plant earthing resistance <5 ohm)
    iv. IS 62305 (Parts 1–4) – Protection Against Lightning (lightning protection system design; independent earth resistance <5 ohm)
    v. IS 1554 (Part 1 & Part 2) – PVC Insulated Electric Cables (FRLS outer sheath; LV power cables up to 1.1 kV only – HT cables above 1.1 kV are governed by IS 7098)
    vi. IS 7098 (Part 1 & Part 2) – Cross-Linked Polyethylene (XLPE) Insulated Cables (for HT power cables from 3.3 kV to 33 kV)
    vii. IS 13947 (Part 4-1):2004 – Low Voltage Switchgear and Controlgear (ACBs, MCCBs, and all LV switchgear used in MCCs, PCCs, and motor control panels)

viii. IS 2026 (Part 1):2011 – Power Transformers (applicable to the step-down transformer 11/33 kV to 0.433 kV, ONAN type; mandatory BIS standard for all power transformers)
ix. IS 325:1996 – Three Phase Induction Motors (for all process motors >0.37 kW; design life 25 years; IP 54 minimum)
x. IS 4691:1985 – Degrees of Protection Provided by Enclosures for Rotating Electrical Machinery (IP classification for all motors and rotating equipment) [Note: IS 4691:1985 is superseded – refer IS/IEC 60034-5:2009 for current IP classification requirements]

9. ELECTRICAL SYSTEMS

The electrical system shall be designed and installed to provide safe, reliable, and continuous power supply to all plant equipment. All electrical works shall comply with applicable Indian Electricity Rules, IS standards, and statutory requirements.

Parameter	Specification
Applicable Standards	i. IS 5571:2009 – Guide for Selection, Installation and Maintenance of Electrical Equipment for Use in Potentially Explosive Atmospheres (for all field equipment in Zone IIA/IIB areas) ii. IS 5572:2009 – Classification of Hazardous Areas having Flammable Gases and Vapours for Electrical Installations (HAZOP/QRA basis; all plant area classification) iii. IS 3043:2018 – Code of Practice for Earthing (Second Revision) (separate PLC/DCS earthing; overall plant earthing resistance <5 ohm) iv. IS 62305 (Parts 1–4) – Protection Against Lightning (lightning protection system design; independent earth resistance <5 ohm) v. IS 1554 (Part 1 & Part 2) – PVC Insulated Electric Cables (FRLS outer sheath; LV power cables up to 1.1 kV only – HT cables above 1.1 kV are governed by IS 7098) vi. IS 7098 (Part 1 & Part 2) – Cross-Linked Polyethylene (XLPE) Insulated Cables (for HT power cables from 3.3 kV to 33 kV) vii. IS 325:1996 – Three Phase Induction Motors (for all process motors >0.37 kW; design life 25 years; IP 54 minimum) viii. IS 4691:1985 – Degrees of Protection Provided by Enclosures for Rotating Electrical Machinery (IP classification for all motors and rotating equipment) [Note: IS 4691:1985 is superseded – refer IS/IEC 60034-5:2009 for current IP classification requirements]
Power Supply	3-Phase, 11 kV / 33 kV, 50 Hz (State Electricity Board)
Step-Down Transformer	11–33 kV / 0.433 kV, ONAN Type

LV Distribution	415 V, 4-Wire, 50 Hz MV Switchboard
Emergency Power	DG Set with AMF Panel (Dual Incomer + Bus Coupler) DG Set shall comply with CPCB emission norms (CPCB notification dated 16 November 2018 and amendments) and shall be provided with acoustic enclosure (noise ≤ 75 dB(A) at 1 metre from enclosure per CPCB guidelines).
UPS (Control System)	Dual Redundant Online UPS; 2×100% Ni-Cd Batteries; min. 60 min (120 min for instruments) backup
Motor Oversize Margins	>55 kW: 10%; 22–55 kW: 15%; <22 kW: 25%
Motor Design Life	25 years; IP-54 minimum (IP-55 for terminal box)
Voltage Drop – Power Circuits	≤ 4%
Voltage Drop – Lighting Circuits	≤ 2%
Hazardous Area Equipment	Flameproof / Ex-d Certified; IS 5571 / IEC 60079 Compliant
Earthing Standard	As per IS 3043; separate PLC/DCS earth; resistance <5 ohm
Lightning Protection	As per IS 62305; independent earth resistance <5 ohm
Cable Standard (PVC Insulated)	IS 1554; FRLS Outer Sheath
Cable Standard (XLPE Insulated)	IS 7098
Area Classification Analysis	As per IS 5572; mandatory HAZOP / QRA by third party

10. INSTRUMENTATION & CONTROL SYSTEM (ICSS)

The Instrumentation, Control, and Safety System (ICSS) shall be designed to ensure safe, efficient, and fully automated plant operation. The system shall provide continuous monitoring, automatic control, alarm management, and data logging capabilities.

Parameter	Specification
Applicable Standards	i. IS 16087:2016 – Specification for Bio-Gas/Bio-Methane (product quality standard against which CBG at supply point shall be certified) ii. PNGRB (Technical Standards for Natural Gas Pipelines) Regulations – Applicable to CGD offtake pipeline design and commissioning; pressure-controlled termination at 20 bar g at plant boundary iii. OISD-STD-179 – Safety Requirements for CNG Compression, Storage and Handling (for pressure regulating skid, slam-shut valve, metering skid,

	and cascade designs) iv. SMPV (Unfired) Rules 2016 / Gas Cylinder Rules 2016 – Statutory requirements under Explosives Act for gas holders, cascade cylinders, high-pressure storage vessels and pressure relief devices (PESO approval)
Flow Measurement	Thermal Mass Flow Meters for biogas lines
Pressure Transmitters	Smart HART; 4–20 mA; ±0.1% accuracy
Temperature Sensors	Pt100 RTD with non-corrodible metal sheath
Gas Detectors	CH_4 and H_2S; ATEX / PESO certified; integrated with SCADA
Fire Alarm System	Addressable microprocessor-based; clean agent suppression for control rooms
Instrument Protection	IP65 / NEMA 4X; Ex-d for Zone 1; Ex-e / Ex-n for Zone 2

11. MAJOR EQUIPMENT SUMMARY

The following table provides a consolidated summary of the major equipment and their key specifications for the CBG Production Plants:

Equipment	Key Specification	Material of Construction	Suggested Makes
H_2S Scrubber	Packed bed chemical scrubber, >98% H_2S removal	FRP / SS316L	Pentair / CECO / Duall India
Dehumidifier	Refrigerant-based, outlet dew point 5°C	SS316L	Atlas Copco / Parker / SPX Flow
Activated Carbon Filter	Dual bed lead-lag, <3 ppm H_2S outlet	SS316 / CS with epoxy lining	TIGG / CPL / Jacobi
VPSA System	Methane purity ≥95%, recovery >96%	CS with epoxy lining / SS316L	Xebec / Bright Renewables / Mahler AGS
Membrane Unit (Optional)	Two-stage polishing, methane purity ≥99%	SS304L / SS316L	Air Liquide MEDAL / Evonik SEPURAN / Generon
CBG Compressor	Oil-free reciprocating, ISO 13631	Oil-free biogas grade	BAUER / Ariel / Sauer
Gas Storage Balloon	Double membrane, 1500 m^3 minimum capacity	PVC with PVDF coating	Sattler CENO / WELTEC BIOPOWER
Gas Piping	ASME B31.3 compliant process piping	SS304L / SS316L	Jindal / Ratnamani / Maharashtra Seamless

12. PLANT BUILDINGS

12.1 Control and Monitoring Building With Electrical Panel Room

A dedicated Control and Monitoring Building shall be provided at each plant site to house the PLC panels, SCADA workstation, UPS systems, and operator facilities. The building shall be designed to support round-the-clock plant monitoring and operation, with adequate environmental controls, fire protection, and safety systems.

Parameter	Specification
Building Size (Minimum)	4 m × 5 m (or as required for equipment layout)
Building Type	RCC + Insulated Pre-Engineered Building
Flooring	Anti-static Vitrified Tiles
Air Conditioning	Split Air-Conditioning System
Lighting	LED Lighting with minimum 300 Lux illumination
UPS Backup	Minimum 120 minutes
Printer	Laser Printer with Network Connectivity
Fire Protection	Smoke Detectors and Portable Fire Extinguishers
CCTV Monitoring	Provision for CCTV Monitoring System (minimum 60-day backup)
Earthing	Dedicated Instrument and Electrical Earthing Systems
Suggested Makes	Siemens / Schneider Electric / Rockwell Automation

12.2 Purification Plant PEB Enclosure

The key units of the purification plant shall be housed inside a Pre-Engineered Building (PEB) in structural steel at each plant site. The building shall be designed to support round-the-clock plant operations, monitoring and with adequate environmental controls, fire protection, and safety systems with necessary lighting and ventilation in accordance to prudent industry standards and applicable laws.

Parameter	Specification
Building Size (Minimum)	Minimum 25 m × 18 m x 7.5m (or as required for equipment layout)
Building Type	RCC + Insulated Pre-Engineered Structure
Applicable Standards	i. IS 800:2007 – Code of Practice for General Construction in Steel (mandatory for PEB structural steel design) ii. IS 875 (Part 3):2015 – Wind Loads on Buildings and Structures (Bangalore: Wind Zone II, basic wind

	speed 33 m/s – to be used for PEB structural design)
Corrosion Prevention	Blast Clean Sa 2.5 + Epoxy Primer + PU Coating Layer
Lower Civil Splash Wall:	3.0-meter high reinforced cement concrete (RCC) or solid brick masonry wall from the finished floor level
Roof	Slope 1:8, Total Coated Thickness (TCT) 0.5mm, high-tensile Galvalume steel alloy profiles (AZ150 coating mass) to ensure weatherproofing and corrosion resilience; with necessary ventilation
Flooring	Concrete floor slab featuring chemical-hardened anti-static epoxy screed coatings to eliminate mechanical friction sparks.
Lightning Protection & Earthing	High-voltage surge protection with dedicated chemical pipe earthing matrices conforming to IS 3043:2018, providing static dissipation paths for all structural steel portals and process skids.
Lighting	LED Lighting with minimum 300 Lux illumination
Fire Protection	Smoke/Gas Detectors and Portable Fire Extinguishers
CCTV Monitoring	Provision for CCTV Monitoring System (minimum 60-day backup)

13. ADMINISTRATION BUILDING CUM OFFICE

13.1 Administration Building

A fully furnished, independent Administration Building of minimum 200 m² floor area in two floors shall be provided. It shall not be attached to any process, non-process, or electrical building. Minimum clearance of 3 m on all four sides. The building shall include reception, laboratory room if required, conference hall, engineer's room, pantry, toilet blocks on all floors, master SCADA room. There shall be one Admin Building only as a common facility for all CBG purification plants under the Contract, located at a suitable site as directed by the Authority.

The Administration Building shall be designed and constructed in accordance with the National Building Code of India (NBC) 2016, Parts 3 (Development Control Rules), 4 (Fire and Life Safety), and 8 (Building Services). NBC 2016 compliance is mandatory for all public institutional buildings in India.

14. Operation & Maintenance (O&M) Requirements

14.1 General O&M Requirements

The Concessionaire shall be responsible for carrying out preventive, routine, corrective, and breakdown maintenance of the complete CBG facility, including all mechanical, electrical, instrumentation, and process systems such as tanks, vessels, pumps, compressors, blowers, agitators, piping, valves, membranes, filters, and associated auxiliaries. The objective shall be to ensure uninterrupted round-the-clock operation, maximum plant productivity, and reliable performance throughout the O&M period.

The Concessionaire shall deploy an adequate number of skilled and unskilled personnel for continuous operation and maintenance of the plant in all shifts. Additional manpower shall be arranged during monsoon or emergency conditions whenever required to maintain uninterrupted plant operation. All tools, tackles, testing instruments, consumables, and maintenance equipment required for execution of O&M activities shall be arranged and maintained by the Concessionaire at its own cost.

Routine inspection, lubrication, alignment checks, calibration, adjustments, and troubleshooting of equipment shall be carried out in accordance with OEM recommendations and approved O&M manuals. In the event of failure of any rotary or static equipment, the Concessionaire shall conduct detailed failure analysis and submit a report to the Engineer-in-Charge. All breakdown maintenance activities shall be attended immediately to restore the plant to normal operating condition with minimum downtime.

The Concessionaire shall also be responsible for maintaining proper housekeeping of the entire CBG facility including process areas, compressor areas, tank farms, piping corridors, control rooms, internal roads, and pathways. Rectification of leakages, passing valves, and any process losses shall be carried out promptly to ensure safe and efficient plant operation. Any maintenance activity not specifically mentioned herein but required for smooth and reliable functioning of the plant shall also be deemed to be within the scope of the Concessionaire without any additional cost implication to the Authority.

All drawings, manuals, technical documents, calibration records, maintenance logs, and equipment history records shall be maintained properly at BWSSB premises. Such documents shall remain the property of BWSSB and shall be kept updated and maintained in good condition throughout the contract period.

14.2 Civil Maintenance

The Concessionaire shall undertake comprehensive civil maintenance activities for all structures and facilities associated with the CBG plant. The scope shall include housekeeping and cleaning of chemical handling areas, tanks, vessels, pump rooms, compressor rooms, and all process areas. Cleaning of tanks, sumps, and vessels shall be carried out during available shutdown opportunities without affecting plant operation.

The Concessionaire shall also carry out repair and restoration of damaged painting systems, protective coatings, and civil structures resulting from operation and maintenance activities. Any deterioration or damage to RCC structures, flooring, drains, trenches, platforms, foundations, or related civil infrastructure shall be rectified promptly to maintain safe operating conditions.

14.3 Mechanical Maintenance

The Concessionaire shall be responsible for complete mechanical maintenance of all rotating and static equipment including pumps, blowers, compressors, agitators, tanks, vessels, piping systems, filters, membranes, strainers, valves, and associated accessories.

The scope shall include alignment, lubrication, dismantling, assembly, cleaning, flushing, inspection, replacement of worn-out components, and predictive maintenance activities using approved condition monitoring tools such as SPM/IRD systems. Membranes, filters, strainers, bearings, gland packings, seals, gaskets, fasteners, belts, and all other consumables required for reliable operation shall be supplied and replaced by the Concessionaire as required.

The Concessionaire shall also carry out repair and rectification of biogas storage balloons, arresting leakages and ensuring proper gas retention. Weekly predictive maintenance reports for all critical rotating equipment shall be submitted to the Authority. Complete equipment maintenance history and breakdown records shall be maintained throughout the contract period.

14.4 Electrical Maintenance

The Concessionaire shall carry out preventive and corrective maintenance of all electrical systems including motors, transformers, switchgears, MCCs, PCCs, VFDs, UPS systems, battery banks, lighting systems, and associated cabling networks.

Maintenance activities shall include cleaning, tightening of terminals, insulation resistance testing, lubrication of motor bearings, checking cable continuity, replacement of damaged lugs, fault tracing, and rectification of electrical failures. All switchgear panels and control panels shall be periodically cleaned using approved methods to ensure reliable operation.

Lighting fixtures, lamps, accessories, and electrical consumables shall be maintained and replaced as required to ensure minimum illumination standards specified in the technical specifications. Adequate stock of electrical spares including fuses, relays, contactors, lamps, cable jointing kits, and accessories shall be maintained by the Concessionaire at all times.

14.5 Instrumentation Maintenance

The Concessionaire shall be fully responsible for operation, calibration, servicing, and maintenance of all instrumentation and control systems including PLCs, SCADA systems, field instruments, analyzers, control valves, shutdown valves, sensors, transmitters, and communication systems.

The scope shall include routine inspection, cleaning, calibration, testing, troubleshooting, and replacement of defective instrumentation components. All control panels, field instruments, analyzers, and associated accessories shall be maintained in healthy operating condition as per OEM recommendations and plant requirements.

The Concessionaire shall ensure continuous availability and accuracy of all online analyzers and instrumentation systems. Calibration gases, chemicals, reagents, consumables, communication devices, software tools, and specialized testing equipment shall be arranged by the Concessionaire at its own cost.

Personnel deployed for instrumentation maintenance shall possess adequate knowledge of PLC logic, interlocks, sequencing, SCADA systems, and process instrumentation associated with CBG facilities. Any support required from OEMs or control system manufacturers shall be arranged by the Concessionaire without additional cost to the Authority.

14.6 General Requirements

The Concessionaire shall be responsible for complete coordination and management of all O&M activities, manpower deployment, reporting systems, safety practices, inventory management, and compliance requirements associated with the CBG plant.

The Concessionaire shall ensure round-the-clock operation of the plant with proper shift coverage in both field and control room operations. All personnel shall comply with approved safety procedures, work permit systems, PPE requirements, and occupational health standards.

A fully functional multidisciplinary maintenance workshop with adequate tools, tackles, calibration facilities, and spare inventory shall be maintained at site to minimize plant downtime. The Concessionaire shall also establish and operate a laboratory facility for monitoring process performance and gas quality parameters.

Comprehensive daily, weekly, monthly, quarterly, and half-yearly reports covering plant operation, maintenance activities, gas production, utility consumption, chemical inventory, laboratory results, equipment performance, and downtime analysis shall be submitted to the Authority in approved formats.

In the event of failure to repair or replace faulty equipment within stipulated timelines, the Authority reserves the right to undertake such repairs at the risk and cost of the Concessionaire, and the corresponding expenses shall be recovered from the Concessionaire’s bills.

14.7 Performance Guarantee Test Run (PGTR)

The Performance Guarantee Test Run (PGTR) shall be conducted to verify the performance, capacity, gas quality, safety systems, and operational reliability of the complete CBG plant and all associated sub-systems.

The Concessionaire shall submit a detailed methodology, sequence and protocols of all tests to be undertaken as part of Performance Guarantee Test Run (PGTR) and the Independent Engineer shall verify and agree on the methodology and protocols. Any additional requirements and protocols suggested by the Independent Engineer, shall be adopted and adhered by the Concessionaire and the final PGTR protocol shall be agreed between the Parties at least 120 days before the probable date of commencement of PGTR.

The PGTR shall be considered successfully completed only when the plant continuously produces purified CBG meeting guaranteed quality parameters and specified gas recovery for three consecutive days at the required operating pressure.

The following additional PGTR acceptance criteria shall apply: (i) Plant availability during the PGTR period shall be minimum 90%; (ii) CBG product gas quality samples shall be collected and analysed at minimum every 4 hours during PGTR; (iii) The plant shall operate at not less than 80% of contracted design capacity for the duration of the PGTR; (iv) Methane recovery efficiency and methane slip loss from the complete system shall be measured and recorded continuously during the PGTR; (v) Any unplanned interruption exceeding 2 hours shall invalidate the PGTR run and require a complete restart of the 72-hour test period.

All tests shall be conducted by the Concessionaire in the presence of the Independent Engineer (IE) and Authority representatives. Calibration certificates of all testing instruments shall be submitted at least seven days prior to commencement of the PGTR. The PGTR shall be preceded by the successful completion of the Factory Acceptance Test (FAT) and Site Acceptance Test (SAT) as specified under the SCADA & Automation System requirements (Section 7) and the General Specifications of this Contract. The FAT and SAT protocols, test criteria, and acceptance standards shall be as per the requirements set out in the General Specifications and as approved by the Independent Engineer.

15. Suggested Vendors

The suggested vendors or manufacturers listed in this specification are intended to establish a minimum standard of quality, reliability, and performance for electro-mechanical, instrumentation, automation, and process equipment used in hazardous biogas environments. These are indicative references only and do not constitute an exclusive approved list.

All proposed equipment shall be sourced from reputed manufacturers having proven experience in industrial process applications, particularly in biogas, wastewater treatment, oil & gas, or hazardous process industries. Any alternate vendor proposed by the Concessionaire shall demonstrate equivalent or superior technical capability, supported by performance certificates, reference installations, ISO certification, and proven after-sales support infrastructure.

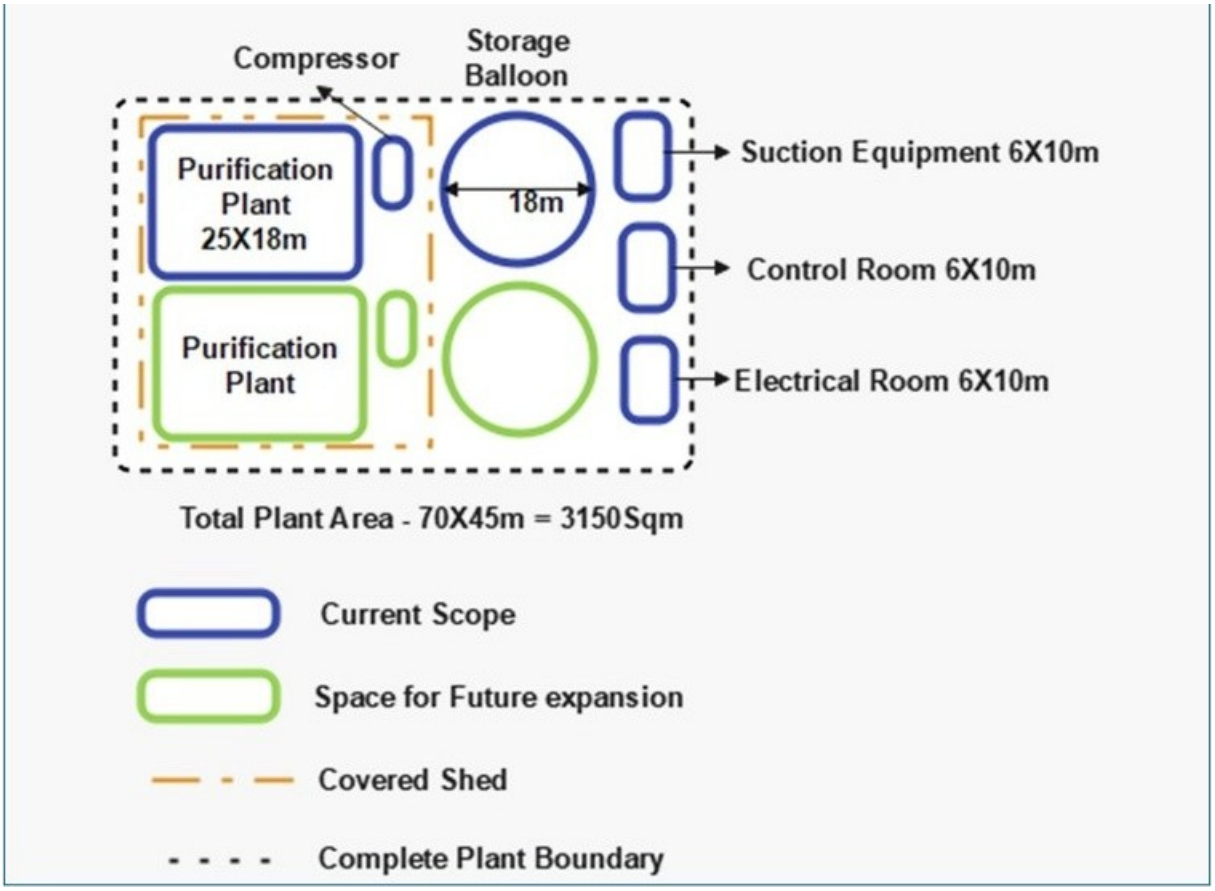
The Authority reserves the right to review and approve or reject alternate makes based on technical evaluation, past performance, availability of service support, and compliance with project specifications.

Annexure 1 – Location Key Maps of the proposed sites

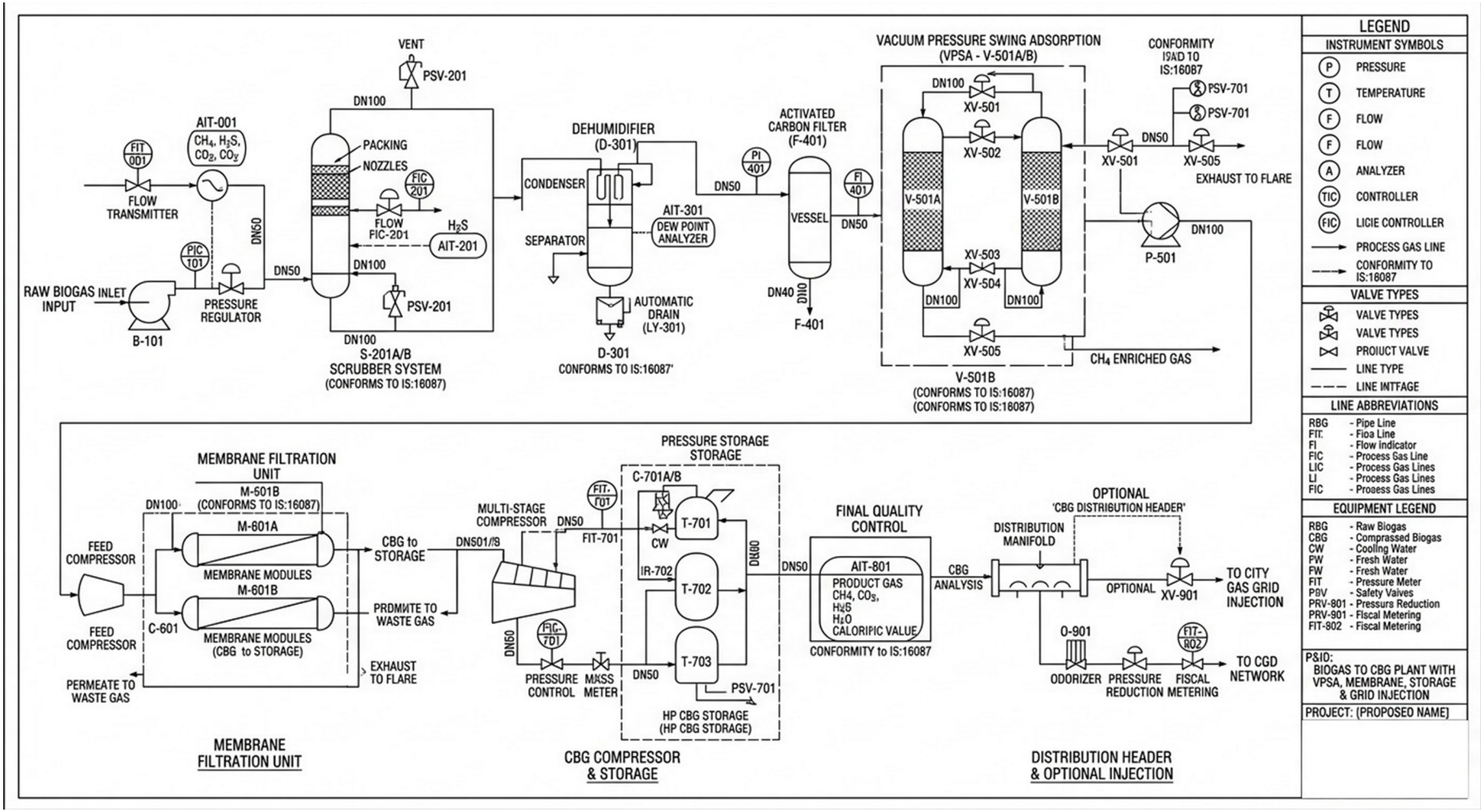
Bellandur Aminakare STP
Legend
Purification Plant 3K Sqm
Google Earth

K&C Valley 150 and 60mld STPs
Legend
K&C
Purification Plant 4k Sqm
Google Earth

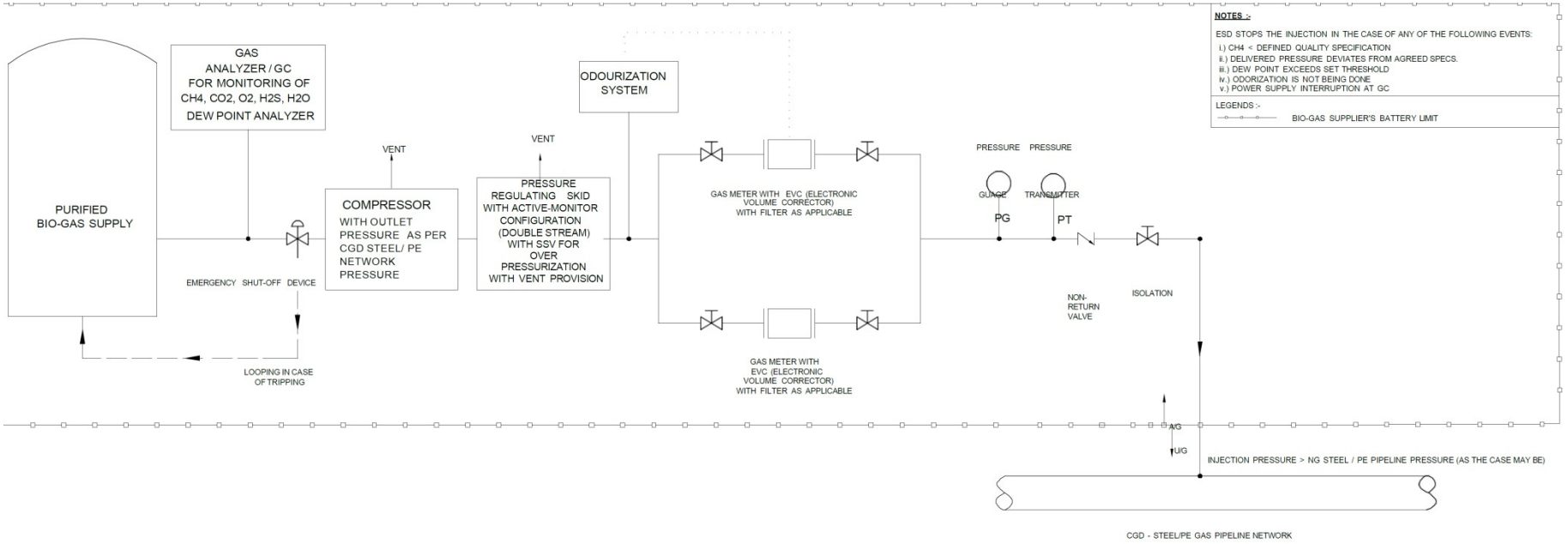
Annexure 2 – Indicative Layout of a Plant (15,000 m³/day Capacity)



Annexure 3 – Indicative P&I Diagram (For Guidance Purpose Only)



Annexure 4 – Typical Schematic for Biogas Injection into CGD Steel/PE Pipe Network


NOTES :-
ESD STOPS THE INJECTION IN THE CASE OF ANY OF THE FOLLOWING EVENTS:
i.) CH4 < DEFINED QUALITY SPECIFICATION
ii.) DELIVERED PRESSURE DEVIATES FROM AGREED SPECS.
iii.) DEW POINT EXCEEDS SET THRESHOLD
iv.) ODORIZATION IS NOT BEING DONE
v.) POWER SUPPLY INTERRUPTION AT GC
LEGENDS :-
BIO-GAS SUPPLIER'S BATTERY LIMIT
PURIFIED BIO-GAS SUPPLY
GAS ANALYZER / GC FOR MONITORING OF CH4, CO2, O2, H2S, H2O DEW POINT ANALYZER
DEW POINT ANALYZER
EMERGENCY SHUT-OFF DEVICE
LOOPING IN CASE OF TRIPPING
VENT
COMPRESSOR WITH OUTLET PRESSURE AS PER CGD STEEL/ PE NETWORK PRESSURE
VENT
PRESSURE REGULATING SKID WITH ACTIVE-MONITOR CONFIGURATION (DOUBLE STREAM) WITH SSV FOR OVER PRESSURIZATION WITH VENT PROVISION
ODOURIZATION SYSTEM
GAS METER WITH EVC (ELECTRONIC VOLUME CORRECTOR) WITH FILTER AS APPLICABLE
GAS METER WITH EVC (ELECTRONIC VOLUME CORRECTOR) WITH FILTER AS APPLICABLE
PRESSURE
GUAGE
PG
PRESSURE
TRANSMITTER
PT
NON-RETURN VALVE
ISOLATION
AVG
UG
INJECTION PRESSURE > NG STEEL / PE PIPELINE PRESSURE (AS THE CASE MAY BE)
CGD - STEEL/PE GAS PIPELINE NETWORK

Annexure 5– Gas Generation Study

Disclaimer: This annexure contains excerpts from the technical study for the reference for the bidder. The information is merely to indicate the potential of biogas from the STPs and shall not be construed from basis of any conditions of the contract.

1. Biogas generation potential of the sludge

The gas generation potential is evaluated by first estimating the amount of sludge produced and then determining how much of it can be treated to generate biogas. This section presents the potential for biogas generation from the sludge handled at each of the plantsThe section then presents the actual biogas generation including its quality and quantity and presents an assessment of potential measures to improve the quality and quantity of the biogas.

1.1 Sludge generation in each STP

Table 1: Details of Sludge generation in each STP

Name of STP	Flow MLD	TSS removed mg/l	TSS removed, kg/d	BOD Load removed in secondary	Net Sludge contribution @0.25 kg/ kg BOD	Total qty of sludge including	Sludge, kg/ML
Hebbal	100	222	22200	17.05	4263	26463	265
V Valley	150	147	22050	13.0	3262	25312	169
K & C Valley 150	150	152	22800	21.2	5303	28103	187
K & C Valley 60	60	171	10260	7.9	1971	12231	204
Bellandur	90	182	16380	13.0	3240	19620	218

To understand actual biogas generation potential, treatability studies were conducted using the actual sludge from the STPs.

1.2 Treatability studies using sludge

Treatability studies were undertaken basically by simulating the standard digester operation, but at a highly controlled operational conditions which can optimize substrate biomass: HRT ratio, level of mixing, temperature and pressure, foam control and nutrient additions.

1.2.1 Setup for treatability studies

The pilot digester has variable feed capacity in the range of 1-5 litres per day. The sludge is first thickened using a mechanical thickener at desired solids concentration (>5%) and then fed to the digester. The three zones of anaerobic digestion can be studied independently.

Figure 1: Pilot Digester

Acidogenesis was conducted at different temperatures to evaluate the potential improvements achievable through thermophilic digestion compared to mesophilic digestion. Various mixing intensities were examined, ranging from no external mixing to recirculation-based mixing at approximately 1–2 W/m³, and paddle mixing within the range of 2–15 W/m³.

The process was also assessed under different operational conditions, including with and without substrate recirculation, and with or without biogas bubbling, to ensure a comprehensive evaluation.

Key performance parameters such as biogas pressure, methane content, and digestate solids percentage were systematically analyzed.

1.2.2. Details of samples collected for treatability studies

For the treatability studies, sludge samples were collected prior to the thickening process. A total of 50 liters of sludge was obtained from each of the five STPs equipped with digesters. A specialized testing equipment was used to assess digester performance under various operational conditions, based on online readings to determine optimal values for best results.

1.2.3 Results of sludge treatability studies – thickness, mixing, temperature

i) Level ofthickening

The optimal sludge feed concentration for the mesophilic reaction appears to be in the range of 5-6% of solids concentration with about 70% VSS. For thermophilic reactions, the optimal input solids concentration can be 8-9% with 70% VSS.

The present sludge values vs the difference from optimum values can be as follows:

Table 2: The present sludge values vs the optimum values

Name of the STP	Present sludge concentration, %	Difference from optimum	Present VSS %
Hebbal	2.1%	-2.9%	45%
V Valley	4.4%	-0.6%	68%
K & C Valley 150	4.5%	-0.5%	62%
K & C Valley 60	3.8%	-1.2%	59%
Bellandur	4.5%	-0.5%	64%

ii) Effect of higher level of digestermixing

Adequate mixing in the digester is crucial and helps the digestion process through

a) Prevention of stratification, i.e., formation of layers with different temperatures or solids concentrations within thedigesters.
b) Homogeneous distribution of sludge andmicroorganisms.
c) Avoidance of scum layer formation on the surface and grit settling at thebottom.
d) Enhanced heattransfer.
e) Release of biogasbubbles.

Mixingcanbeachievedthroughmechanicalmixers(submersibleordrafttube),biogasrecirculation,or hydraulic jet mixing. The intensity and duration of mixing needs to be optimized based on the density and characteristics of the feedsludge.

At present, all the digesters in the STPs studied are getting the vessel contents mixed, mostly using a recirculation line.

Thecontinuouspumpingofmiddlelevelofcontentsofthedigestersbacktotheinlethastwofunctio
ns. On the one hand, it provides adequate mixing in the digester to prevent any settling of
bio-sludge and on the other, it serves as effective inoculum for the sludge being fed into
thesystem.

However, the mixing power provided at present is low, which while saving energy for the mixing, does not serve as an intensive mixing.

Tounderstandtheimpactofmixingandtoverifyifamechanicalmixerisneededtoimprovethedigester performance, the treatability study unit was operated at different mixing power anzd the results are as follows:

Table 3: Performance of Digester Under Different Mixing Conditions

Name of STP	Biogas generation ml/litre of feed at different mixing levels				
	No mixing (only gas movement)	Moderate mixing (4W/m^3)	improvement over no mixing, %	Vigorous mixing (20 W/m^3)	improvement over no mixing, %
Hebbal	52	72	27.78	73	28.77
V Valley	59	73	19.18	77	23.38
K & C Valley 150	58	73	20.55	74	21.62
K & C Valley 60	57	72	20.83	74	22.97
Bellandur	59	76	22.37	78	24.36

It was observed that in the absence of active mixing, where circulation was driven solely by gas movement, the performance of the digester was significantly lower. However, increasing the intensity of mixing did not lead to substantial improvements, suggesting that the sludge was not dense enough to require vigorous agitation to remain in suspension.

This indicates that while it is technically possible to enhance efficiency by replacing the existing mild mixing system with a more vigorous one, such as a submersible mixer, the marginal gains in performancedonotjustifytheadditionalpowerconsumption.Inotherwords,althoughhighereffiency canbeachievedthroughmoreintensivemixing,theimprovementisminimalandtheassociatedenergy costs make it economicallyunviable.

iii) Effect of temperature in digester performance

Highertemperaturetypicallyresultsinfasterdigestionthroughincreasedmetabolicratesandgrowthof anaerobic bacteria and improves the performance. Higher temperature also ensures better pathogen reduction and hence safer disposal of thedigestate.

At present, the digesters studied have a mild heating system by using the thermal energy available in thefluegas.Thecorrespondingincreaseintemperatureofthedigestercontentsisapprox.2-3degree Celsius and consequently is expected to provide digestionimprovement.

Treatability studies were conducted at varying temperatures to assess the effect of temperature on digestion.Importanceofassessingdigesterperformancelinkedtotemperatureisdueto(a)Bangalore, unlikeothercitiesinIndia,couldbecoolerandaheatingsystemmaybeofbetterusethanothers,and (b) thepresentsystemoffluegasheatingwouldnotbeavailableifthebio-gasisusedforanypurpose other than electric powergeneration.

The results from the study were as follows:

Table 4: Performance of Digester Under Different Temperature Conditions

Name of STP	Sludge fed %	Biogas generation ml/litre of feed at different temperature levels and the percentage of improvement over ambient temperature (considered as30 degreecelcius)						
		30-degree celcius	35-degree celcius	% Increase	45-degree celcius	% Increase	60-degree celcius	% Increase
Hebbal	5.2 %	70	72	2.78	88	18.18	134	48%
V Valley	4.8 %	71	73	2.74	94	22.34	142	50%
K & C Valley 150	5.1 %	70	73	4.11	92	20.65	131	47%
K & C Valley 60	5.1 %	70	72	2.78	98	26.53	122	43%
Bellandur	5.1 %	72	76	5.26	102	25.49	132	45%

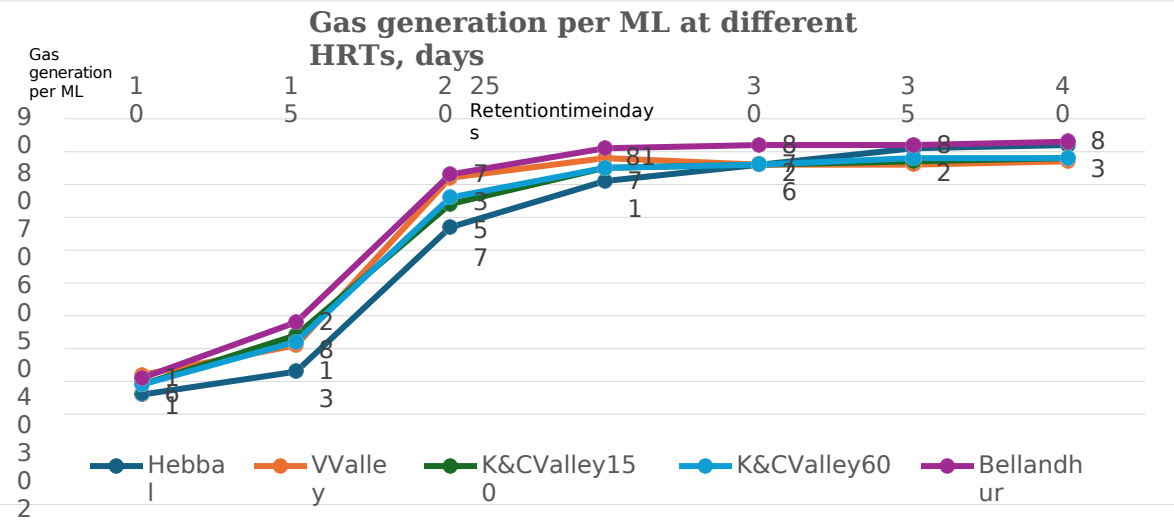
Increase of temperature can have significant improvement, up to about 40-50% by converting existing mesophilic system into thermophilic process. However, two factors need to be considered while evaluating the option of conversion.

(a) The digesters in testing are already existing and modifying this to a thermophilic system may need significant changes and costs additional expenditure, which could besizeable.
(b) About 25-35% of the gas produced may be needed for heating the digesters and this considerably reduces the extrabenefit.

2. Comparison of biogas generation potential and actual biogas generation

2.1 Present gas generation for varying HRT

Thegasgenerated(ml/ liter)quantityestimationwasconvertedintocubicmeterofgaspermillionliters of sewage. The hydraulic retention time (HRT) for optimum gas generation for the present sludge without



any enhancement was studied. The result obtained was asfollows:

Figure 2: Gas generation from the present sludge at existing condition

The retention time to get a gas generation of 75 m^3/ML and the actual generation is as follows:

Table 5: Comparison of Retention Time to the actual Biogas Generation for the STPs

Name of the STP	Temperature maintained, deg C	Solids concentration maintained	Optimum HRT	Gas qty generated, ml/l (m^3/ML)	Actual gas at present (m^3/ML)	Difference in %
Hebbal	35	5	28 days	76	20	-280
V Valley	35	5	25 days	78	57	-37
K & C Valley 150	35	5	25 days	77	56	-38
K & C Valley 60	35	5	25 days	77	60	-28
Bellandur	35	5	24 days	81	66	-23

2.2 Status of the digesters

This section presents assessment of status of the digesters in terms of their active volume and active mixing time. Normally a tracer study using lithium chloride or any tracer chemical which does not degrade immediately with anaerobic digestion is used to determine active reactor volume. However, thedigestersinBangaloreoperatewithrecirculationlinesformixing.Therefore,tracerstudycouldhave resulted in a faulty RTD curve. Hence, first the HRT was calculated based on the design values and plotted against average daily flow rate. This value was then compared with solid mass balance by monitoring the total solids entering & leaving the digester, plotting it against the daily sludge flow rate. Based on these values the approximate volume loss has beenestimated.

The estimations indicated that no significant loss of digester volume occurs in the operation period, although some of the digesters were in operation for a long time.

In V Valley and K &C valley (150) digesters this appears to be less than 10% (up to 25% is considered acceptable). In Hebbal, K & C valley (60) and Bellandur the loss in volume is estimated at 22%, 17% and 19% respectively which means these digesters may need to be de-sludged in 1-2 years' time for better performance. However, upto 25% loss in volume is generally considered acceptable.

2.3 Theoretical biogas generation vs actual

The theoretical generation of biogas from the five STPs where the sludge is withdrawn and digested is given below:

Table 6: The theoretical generation of biogas from the five STPs

Parameter	**Hebbal**	**V Valley**	**K&C Valley**	**K&C Valley**	**Bellandur**
	100	**150**	**150**	**60**	**90**
	Average	***Average***	***Average***	***Average***	***Average***
TSS load, t/d	38.65	38.6	38.3	18.3	36.4
TSS load after primary, t/d	16.46	16.5	15.5	8.0	20.1
TSS Load removed, t/d	22.19	22.1	22.8	10.3	16.3
VSS removed t/d	9.99	15.0	14.1	6.1	10.5
Total BOD load to Aeration	17.05	13.0	21.2	7.9	13.0
VSS from wasted secondary sludge, t/d (0.18 kg VSS/kgBOD)	3.07	2.3	3.8	1.4	2.3
Total VSS fed to digester	13.05	17.4	18.0	7.5	12.8
Theoretical Gas production, m^3/d	9138	12168	12573	5241	8953
Actual generation, m^3/d	2000	8550	8400	3600	5940

From the performance of the anaerobic digestion during the treatability studies, the

potential gas generation at 35ºC with moderate mixing has been worked and then compared with actual generation at present.

Table 7: The potential generation of biogas from the five STPs

Name of the STP	Capacity	Gas production, ml/lite(after scrubbing)	Potential gas generation based ontreat. Studies,m^3/d	Actual value at present (m^3/d)	Gap (potential for additional generation)
Hebbal	100	72	7200	2000	5200
V Valley	150	73	10950	8550	2400
K & C Valley 150	150	73	10950	8400	2550
K & C Valley 60	60	72	4320	3600	720
Bellandur	90	76	6840	5940	900
Total			40260	28490	11770

It is clear that the actual gas generation is much less compared to the theoretical.

2.4 Purity of biogas produced

The purity of biogas produced from the treatability studies have been monitored online by the instruments in it. Online instruments are available to check the gas before and after scrubbing(ventury scrubbing with sodium hydroxide). The values obtained before and after scrubbing are as follows:

Table 8: Quality observed in the biogas generated before scrubbing

Name of STP	Quality observed in the biogas generated before scrubbing							
	Methane content (%)	Carbon dioxide (%)	Hydrogen Sulphide (%)	Nitrogen (%)	Water Vapour (%)	Hydrogen (%)	Siloxanes (%)	Ammonia
Hebbal	58.0	36.0	1.20	0.83	2.20	0.60	0.02	1.10
V Valley	66.5	31.0l	1.10	0.20	0.90	0.05	0.00	0.20
K & C Valley 150	67.0	31.0	0.80	0.30	0.60	0.02	0.01	0.22
K & C Valley 60	62.2	33.5	1.10	0.70	1.40	0.20	0.05	0.80
Bellandur	65.2	31.6	1.10	0.60	1.10	0.10	0.01	0.24

Table 9: Quality observed in the biogas generated after dehumidifier and scrubbing

Name of STP	Quality observed in the biogas generated after dehumidifier and scrubbing							
	Methane content (%)	Carbon dioxide (%)	Hydrogen Sulphide (%)	Nitrogen (%)	Water Vapour (%)	Hydrogen (%)	Siloxanes (%)	Ammonia
Hebbal	69.0	29.0	0.01	0.05	1.60	0.20	0.00	0.09
V Valley	72.0	26.9	0.01	0.05	0.90	0.05	0.00	0.08
K&C Valley 150	73.0	26.0	0.02	0.06	0.60	0.02	0.01	0.24
K&C Valley60	70.2	27.6	0.02	0.05	1.20	0.10	0.00	0.78
Bellandur	71.5	27.1	0.04	0.05	0.98	0.20	0.00	0.08

It could be seen that quality of biogas after scrubbing is in line with good quality biogas obtained in similar biogas projects elsewhere.

2.5 Likely quantity and weight of pure biogas after enrichment of methane

Table 10: Likely quantity and weight of pure biogas after enrichment of methane

Name of STP	Quantity of raw biogas, ml/litre	Weight of the raw biogas, g/ml	STP capacity, MLD	Qty of gas likely, m^3/d	Wt of raw biogas, kg/d	% of carbon dioxide removed
Hebbal	72	1.15	100	7200	8280	31
V Valley	73	1.12	150	10950	12264	26
K & C Valley 150	73	1.18	150	10950	12921	26
K & C Valley 60	72	1.08	60	4320	4666	28.5
Bellandur	76	1.18	90	6840	8071	26.6
Total			550	**40260**	**46202**	--

Name of STP	Qty of carbon dioxide removed	Wt of carbon dioxide removed, kg/d	Weight of other impurities removed kg/d	Wt of purified biogas kg/day	Kg/ML of sewage
Hebbal	2232	4240.8	248	3791	37.91
V Valley	2847	5409.3	368	6487	43.25
K & C Valley 150	2847	5409.3	388	7124	47.49
K & C Valley 60	1231.2	2339.28	140	2186	36.44

Bellandur	1819.44	3456.936	242	4372	48.58
Total				**23960**	43.56

It is possible to estimate the quantity of saleable biogas from the five digesters at about 22000-24000 kg/day.
The gas generation volume variation, as well as the digester performance, the underlying parameters for gas generation, were analysed as presented in the following subsections